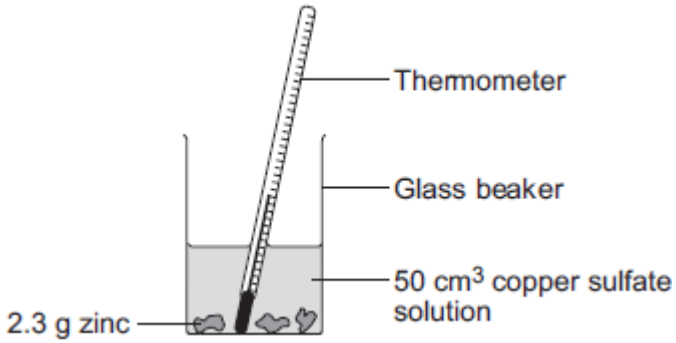
**Q1.** A student investigated the temperature change when zinc reacts with copper sulfate solution.

The student used a different concentration of copper sulfate solution for each experiment.

The student used the apparatus shown below.




The student:

- measured 50 $cm^3$ copper sulfate solution into a glass beaker
- measured the temperature of the copper sulfate solution
- added 2.3 g zinc
- measured the highest temperature
- repeated the experiment using copper sulfate solution with different concentrations.

The equation for the reaction is:

$Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$

zinc + copper sulfate solution ⟶ copper + zinc sulfate solution

(a) The thermometer reading changes during the reaction.

Give **one** other change the student could **see** during the reaction.

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**(1)**

(b) Suggest **one** improvement the student could make to the apparatus.

Give a reason why this improves the investigation.

Improvement .....

.....

Reason .....

.....

**(2)**

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The student's results are shown in the table.

**Table**

| Experiment number | Concentration of copper sulfate in moles per $dm^3$ | Increase in temperature in °C |
|---|---|---|
| 1 | 0.1 | 5 |
| 2 | 0.2 | 10 |
| 3 | 0.3 | 12 |
| 4 | 0.4 | 20 |
| 5 | 0.5 | 25 |
| 6 | 0.6 | 30 |
| 7 | 0.7 | 35 |
| 8 | 0.8 | 35 |
| 9 | 0.9 | 35 |
| 10 | 1.0 | 35 |

Describe **and** explain the trends shown in the student's results.

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**(6)**
**(Total 9 marks)**

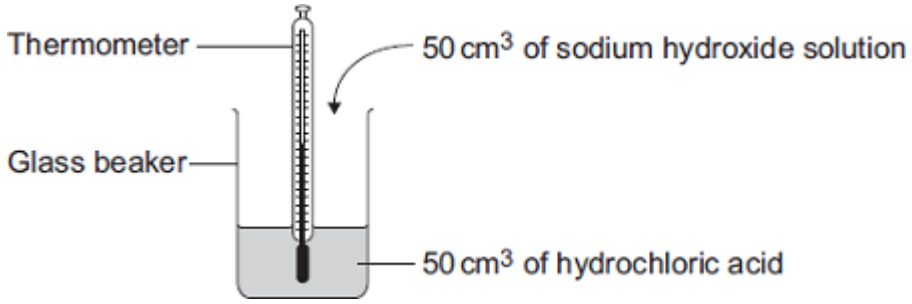
**Q2.** Read the information about energy changes and then answer the questions.

A student did an experiment to find the energy change when hydrochloric acid reacts with sodium hydroxide.

The equation which represents the reaction is:

$$HCl + NaOH \rightarrow NaCl + H_2O$$

The student used the apparatus shown in the diagram.




The student placed 50 $cm^3$ of hydrochloric acid in a glass beaker and measured the initial temperature.

The student then quickly added 50 $cm^3$ of sodium hydroxide solution and stirred the mixture with the thermometer. The highest temperature was recorded.

The student repeated the experiment, and calculated the temperature change each time.

| | **Experiment 1** | **Experiment 2** | **Experiment 3** | **Experiment 4** |
|---|---|---|---|---|
| Initial temperature in °C | 19.0 | 22.0 | 19.2 | 19.0 |
| Highest temperature in °C | 26.2 | 29.0 | 26.0 | 23.5 |
| Temperature change in °C | 7.2 | 7.0 | 6.8 | 4.5 |

(a) The biggest error in this experiment is heat loss.

Suggest how the apparatus could be modified to reduce heat loss.

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.....

**(1)**

(b) Suggest why it is important to mix the chemicals thoroughly.

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**(1)**

(c) Which **one** of these experiments was probably done on a different day to the others?

Give a reason for your answer.

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**(1)**

(d) Suggest why experiment **4** should **not** be used to calculate the average temperature change.

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**(1)**

(e) Calculate the average temperature change from the first three experiments.

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Answer = ..... °C

**(1)**

(f) Use the following equation to calculate the energy change for this reaction.

Energy change in joules = 100 × 4.2 × average temperature change

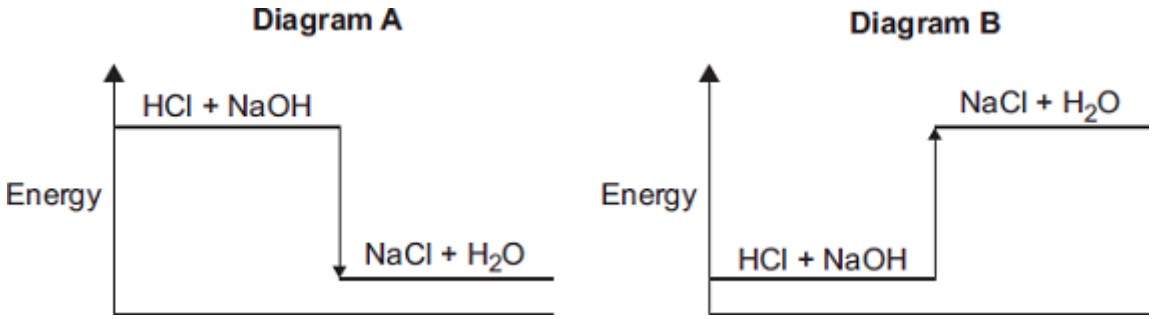
.....

Answer = ..... J

**(1)**

(g) Which **one** of these energy level diagrams represents the energy change for this reaction?

Give a reason for your answer.

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**(1)**
**(Total 7 marks)**

**Q3.** Some cars are powered by hydrogen fuel cells.

**Figure 1**




(a) What type of energy is released by hydrogen fuel cells?

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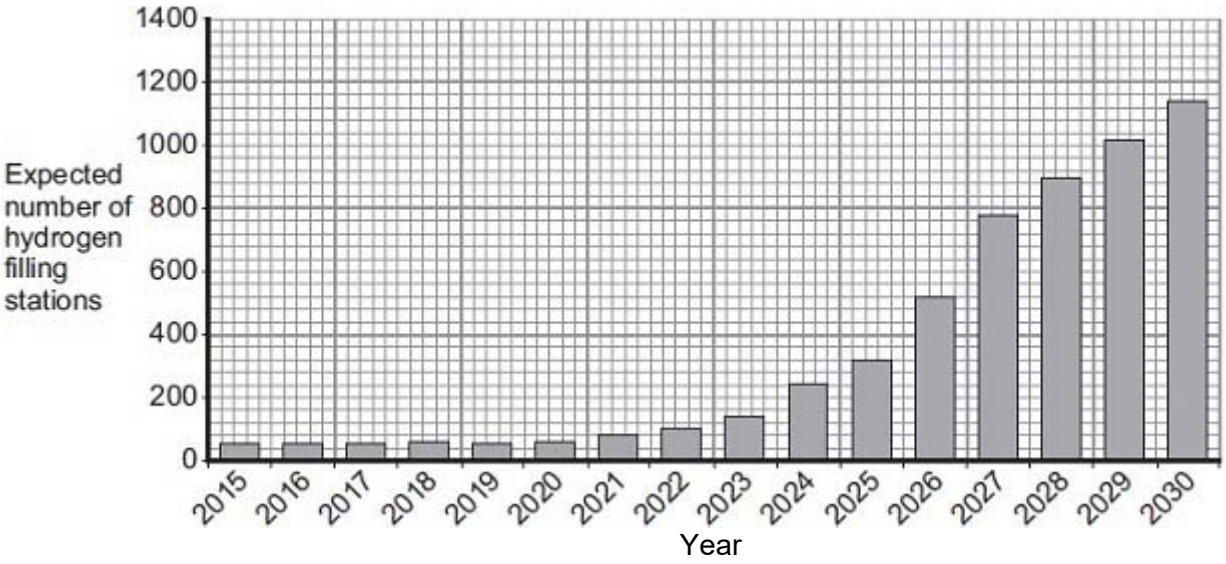
**(1)**

(b) Owners of cars powered by fuel cells buy hydrogen from hydrogen filling stations.

**Figure 2** shows how the number of hydrogen filling stations in the UK is expected to increase up to the year 2030.

**Figure 2**




Use the information in **Figure 2** and your own knowledge to answer this question.

Suggest **two** reasons why the UK government might encourage the building of more hydrogen filling stations.

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**(2)**

(c) The equation for the reaction of hydrogen with oxygen is:

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

During the reaction, energy is used to break the bonds of the reactants.

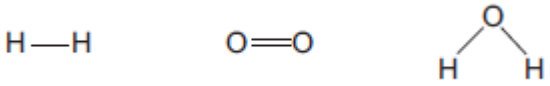
Energy is released when new bonds are made to form the product.

Bond energies for the reaction are given in the table below.

| Bond | Bond energy in kJ |
|---|---|
| | 436 |
| | 498 |
| | 464 |

The structures of the reactants and product are shown in **Figure 3**.

**Figure 3**




hydrogen oxygen water

(i) Calculate the energy change for the reaction:

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

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.....

Energy change = ..... kJ

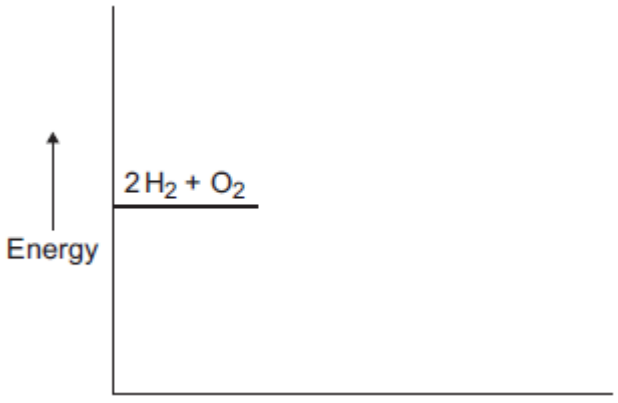
**(3)**

(ii) The reaction of hydrogen with oxygen is exothermic.

Complete the energy level diagram for this reaction on **Figure 4**.

Clearly label the activation energy.

**Figure 4**

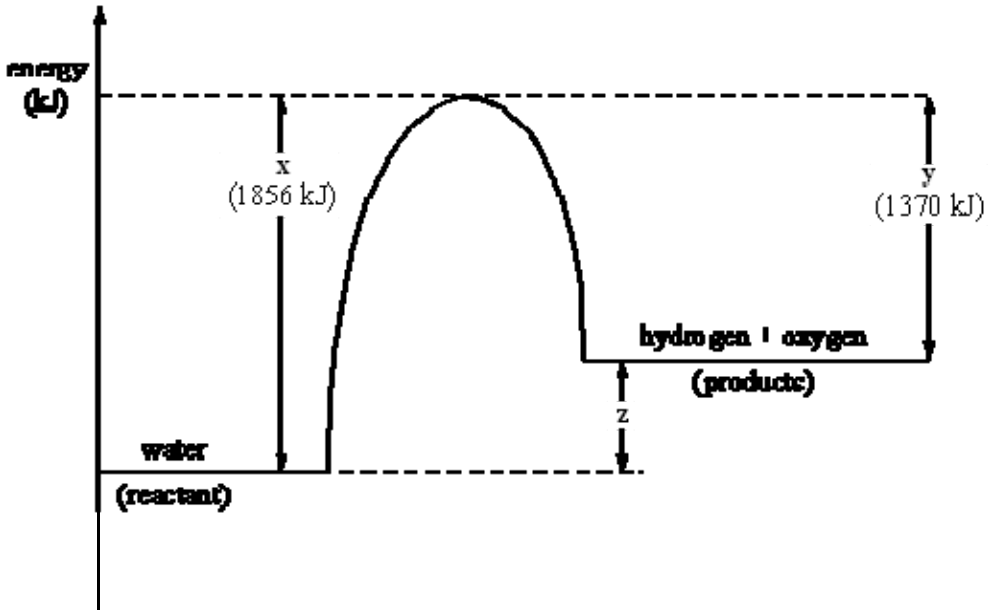



**(3)**
**(Total 9 marks)**

**Q4.** The symbol equation shows the decomposition of water.

$2H_2O \rightarrow 2H_2 + O_2$

An energy level diagram for this reaction is shown below.




Explain the significance of **x**, **y** and **z** on the energy level diagram in terms of energy transfers that occur in the reaction. You should make specific reference to the bonds broken and formed and to the nett energy transfer (energy transferred to or from the surroundings).

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**(Total 6 marks)**

**M1.**(a) any **one** from:

- solution becomes colourless or colour fades
- zinc becomes bronze / copper coloured
  *allow copper (forms) or a solid (forms)*
- zinc gets smaller
  *allow zinc dissolves*
- bubbles or fizzing.
  *ignore precipitate*

**1**

(b) improvement:
use a plastic / polystyrene cup or add a lid
*accept use lagging / insulation*

**1**

reason - must be linked
reduce / stop heat loss
**OR**
improvement:
use a digital thermometer
*allow use a data logger*

reason - must be linked
more accurate or easy to read or stores data
*allow more precise or more sensitive*
*ignore more reliable*
*ignore improvements to method, eg take more readings*

**1**

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a 'best–fit' approach to the marking.

**0 marks**
No relevant content

**Level 1 (1−2 marks)**
There is a statement about the results.

**Level 2 (3−4 marks)**
There are statements about the results. These statements may be linked or may include data.

**Level 3 (5−6 marks)**
There are statements about the results with at least one link and an attempt at an explanation.

Examples of chemistry points made in the response:
**Description:**
**Statements**
Concentration of copper sulfate increases
Temperature change increases
There is an anomalous result
The temperature change levels off
Reaction is exothermic

**Linked Statements**
Temperature change increases as concentration of copper sulfate increases
The temperature change increases, and then remains constant
After experiment 7 the temperature change remains constant

**Statements including data**
The trend changes at experiment 7
Experiment 3 is anomalous

**Attempted Explanation**
Temperature change increases because rate increases
Temperature change levels off because the reaction is complete

**Explanation**
As more copper sulfate reacts, more heat energy is given off
Once copper sulfate is in excess, no further heat energy produced

**6**

**[9]**

**M2.**(a) eg plastic (beaker) / insulation / lid / cover **or** any mention of enclosed

*any sensible modification to reduce heat loss*

*ignore prevent draughts*

*ignore references to gas loss*

*ignore bomb calorimeter*

**1**

(b) all the substances react **or** all (the substances) react fully / completely **or** heat evolved quickly **or** distribute heat

*'so they react' is insufficient for the mark*

*accept increase chances of (successful) collisions / collision rate increase*

*do **not** accept rate of reaction increase / make reaction faster*

**1**

(c) experiment 2 **and**
different / higher / initial / starting temperature

*accept experiment 2 **and** the room is hotter / at higher*

*temperature*

*do **not** accept temperature change / results higher*

**1**

(d) temperature change does not fit pattern

*accept anomalous / odd **or** it is the lowest **or** it is lower than the others **or** it is different to the others*

*'results are different' is insufficient*

**1**

(e) 7 / 7.0

**1**

(f) (100 × 4.2 × 7) = 2940

*ecf from (e)*

**1**

(g) diagram A **and**
reaction exothermic / heat evolved / Δ H is negative / temperature rises

*accept energy is lost (to the surroundings)*

*accept energy of products lower than reactants*

*allow arrow goes downwards*

**1**

**[7]**

**M3.**(a) electrical

**1**

(b) using hydrogen saves petrol / diesel / *crude oil*

*allow crude oil is non-renewable*

*ignore hydrogen is renewable*

**1**

*using hydrogen (in fuel cells) does not cause pollution*

*accept no carbon dioxide produced*

*allow less carbon dioxide produced*

*allow hydrogen produces only water*

**1**

(c) (i) (–)486

*correct answer with or without working gains **3** marks*

*if answer is incorrect:*
*(2 × 436) + 498* ***or*** *1370 gains* ***1*** *mark*
*4 × 464* ***or*** *1856 gains* ***1*** *mark*
*correct subtraction of ecf gains* ***1*** *mark*

**3**

(ii) products lower than reactants

**1**

*reaction curve correctly drawn*

**1**

activation energy labelled

**1**

**[9]**

**M4.** *ideas that*

- x = the energy required / taken in / used* to break the bonds of water / reactant [*<u>not</u> used <u>up</u> / formed]
  *gains 1 mark*
- **but =** the energy required taken in / used to break the bonds in water **or** activation energy
  *gains 2 marks*
- y = the energy released given out when bonds form
  *gains 1 mark*
- **but =** the energy released / given out when hydrogen / oxygen form
  *gains 2 marks*
- z = 1856 – 1370 or (+)486 kJ
  *for 1 mark*

**or** difference between x and y **or** net energy transferred

- overall, energy is taken in / absorbed in the reaction
  **or** the reaction is endothermic **or** energy required to break existing bonds is > energy released when new bonds form
  *for 1 mark*

**[6]**